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On certain morphological features of Bulinus africanus and B. globosus (Mollusca: Pulmonata) and the distribution of these species in south eastern Africa

by

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SYNOPSIS

Examination of samples of *Bulinus* (*Physopsis*) *africanus* (Krauss) and *B.* (*P.*) *globosus* (Morelet) collected near their type localities confirmed the diagnostic value of characters of the copulatory organ. Parasitism by larval trematodes reduced the size of the copulatory organ in *B.* (*P.*) *globosus*. *B.* (*P.*) *africanus* was found to occur further south than *B.* (*P.*) *globosus* in Natal, South Africa.

INTRODUCTION

The freshwater snails belonging to the *Bulinus africanus* (Krauss) species group (= subgenus *Physopsis* Krauss, 1848) are of importance as intermediate hosts of *Schistosoma haematobium* in the transmission of human schistosomiasis (bilharziasis). In Southern Africa the two species *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus* (Morelet) were recognised by Mandahl-Barth (1957), the latest author to revise this subgenus, who considered that the most reliable taxonomic characters were provided by the copulatory organ. However, as copulatory organs of intermediate form were described by Wright (1963) in a group of Angolan populations identified as *B.* (*P.*) *africanus*, it appears that study of the inter- and intra-population variation in this organ is desirable.

In the first part of the present study two samples of *Bulinus* (*Physopsis*) collected from habitats near to the type localities of *africanus* and *globosus* in Natal, South Africa and Angola respectively are compared. The characters selected for detailed study were the relationships between shell length and aperture length and in the copulatory organ between the sizes of the penis sheath and the preputium. These characters were chosen because they were given importance by Mandahl-Barth (1957, 1960) and because they may be readily subjected to quantitative analysis.

In the second part of the present account the distribution is described of *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*, identified on the basis of the copulatory organ, in south eastern Africa.

COMPARISON OF *B.* (*P.*) *africanus* AND *B.* (*P.*) *globosus*

Materials and methods

B. (*P.*) *africanus*—South Africa, Natal: Mhlangana River near its confluence with the

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Umgeni River, Durban. Slowly flowing with abundant aquatic vegetation. Leg. D. S. Brown, 15.4.65, 240 shells measured, 227 specimens dissected.

This locality is approximately 6 miles north of "Port Natal" the type locality according to Krauss (1848).

B. (*P.*) *globosus*—Angola, Luanda Province: Lagoa Dalagosa (flood plain of River Cuanza). The habitat was a large shallow lake, probably periodically flooded by the river, much reduced in size in the dry season when the collection was made. Leg. C. A. Wright, 13.11.57, 198 shells measured, 116 specimens dissected.

This locality is approximately 100 miles south of the type locality which lay in the flood plain of the Rio Dande (Wright, 1963).

Specimens of *B.* (*P.*) *africanus* were fixed in hot formol saline after narcotization for 15 to 20 hours in water containing crystals of menthol. After a few hours in the fixative the specimens were transferred to 75% ethanol in which, after several changes, they were preserved. By this method of fixation a nearly uniform degree of contraction resulted with the majority of the animals projecting a short distance from the apertures of their shells. The specimens of *B.* (*P.*) *globosus* were fixed directly in ethanol after narcotisation with menthol in water and the degree of contraction of the animals was more variable.

Measurements of total shell length (L), shell width (W) and aperture length (ML) were made by means of callipers to the nearest 0·1 mm. (fig. 1). After it had been dissected from the animal, the copulatory organ was gently straightened with forceps and measurements were made of the lengths of the penis sheath and preputium (fig. 2) by means of a scale in the eyepiece of the binocular microscope. The relative thicknesses of these two parts was expressed by recording the penis sheath as thicker, approximately equally thick or thinner than the preputium. Copulatory organs in which the junction between the penis sheath and the preputium was not clearly evident externally were dissected, but this junction was usually indicated by a constriction (fig. 2). Specimens which had the copulatory organ everted outside the body were rejected, but in cases where the proximal part of the preputium, together with the distal part of the penis sheath, was everted into the more distal part of the preputium the lengths were estimated after dissection (figs. 3a and b). In these partly everted organs it was not always possible to estimate the thicknesses of the penis sheath and preputium.

SHELL

Infection with larval trematodes

Larval trematodes which it was not possible to identify were observed, in the course of dissection at a magnification of x 6·25, in over one third of the specimens of *B.* (*P*). *globosus* but none were observed in *B.* (*P.*) *africanus*. The parasites were present usually in the apical whorls and were abundant in the digestive gland. There was apparently a higher incidence of infection in the larger snails; 88% of 17 specimens $>$ 14·95 mm. shell length were positive but only 42% of 49 specimens between 12·95 and 14·94 mm. Although this difference may result from a failure to detect young parasites in the smaller snails, the sample was divided into 'infected' and 'uninfected' groups.

There is a significant difference ($P < 0 \cdot 10$) between the mean ratios of shell length: aperture length (L/ML) for infected and uninfected snails in one out of six class intervals of

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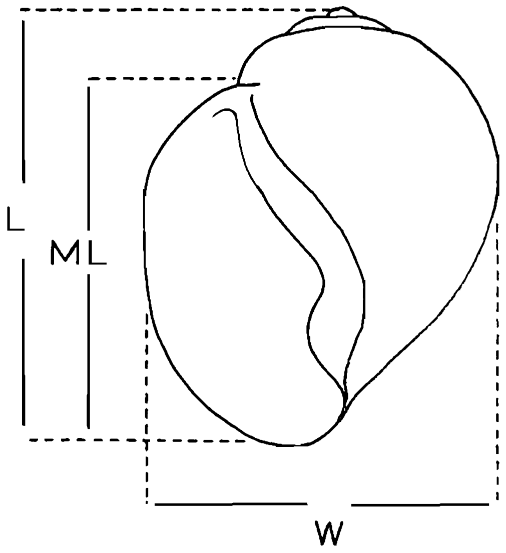

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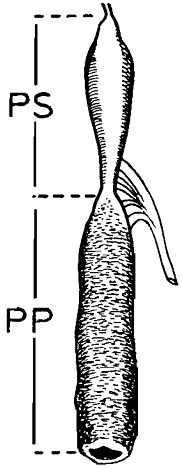

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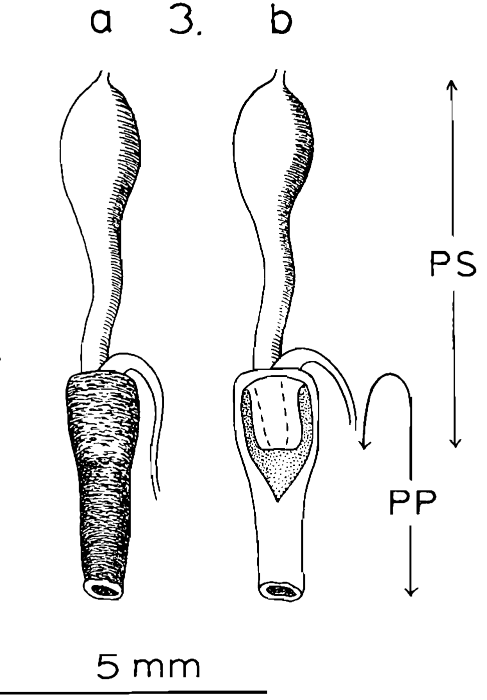

Fig. 1. *Bulinus* (*Physopsis*). Measurements made of the shell. L, shell length; ML, aperture length; W, shell width.

Fig. 2. *B.* (*P.*) *globosus*. Copulatory organ. PS, length of penis sheath; PP, length of preputium.

Fig. 3. *B.* (*P.*) *africanus*. (*a*) entire copulatory organ with penis sheath partly everted into the preputium. (*b*) proximal wall of the preputium dissected away.

shell length (table 1). In this interval the aperture is longer in the infected specimens, but in another interval the opposite is true, so that parasitism does not appear to be responsible for any consistent modification of the ratio L/ML. Likewise there was no significant difference between the ratios of shell length: shell width (L/W) of infected and uninfected specimens (in each class interval of shell length P exceeded 0·40).

Table 1.

B. (*P.*) *globosus* from Lagoa Dalagosa, Angola. The ratio shell length: aperture length (L/ML) compared between specimens infected and uninfected with larval trematodes.
Class intervals of L include ranges of 1·0 or 0·5 mm., e.g., 10·95—11·45 in the 11·0 interval.
*, number of specimens
P, probability that (a—b) is due to chance

Class interval of L	Mean	L/ML	a—b	P
	Uninfected a	Infected b		
11·0	1·23 (13)*	1·30 (3)	— 0·07	< 0·10
11·5	1·25 (5)	1·26 (5)	— 0·01	> 0·80
12·0	1·21 (3)	1·32 (5)	— 0·11	0·05
13·0	1·31 (11)	1·31 (4)	0·00	
14·0	1·30 (7)	1·32 (9)	— 0·02	0·60
14·5	1·35 (5)	1·30 (7)	+ 0·05	0·20

Shell length (L) and aperture length (ML)

B. (*P.*) *africanus*

The extreme values observed for the ratio L/ML were 1·06 and 1·42. Mean values of the ratio L/ML calculated for fourteen class intervals of L increased from 1·11 to 1·37 over the size range of 7·0 to 16·9 mm. shell length, indicating that as growth proceeded the aperture tended to occupy a relatively smaller proportion of the total shell length (Table 2 and fig. 4). Allometric growth was most noticeable over the size range 10·0 to 12·4 mm. shell length when a relatively abrupt change occurred in the rate of increase of L/ML.

B. (*P.*) *globosus*

The extreme values of the ratio L/ML were 1·06 and 1·58. There was an allometric relationship between the rate of growth of the aperture length and the total shell length as described in the case of *B.* (*P.*) *africanus*. Mean values of the ratio L/ML calculated for seventeen class intervals between shell lengths of 5·0 and 16·9 mm. increased from 1·15 to 1·37 (table 2 and fig. 4), the change in shell proportions being most marked between shell lengths of 10·0 and 12·4 mm.

In the majority of corresponding class intervals the mean value of L/ML is greater than in *africanus*, although the ranges of the individual values are closely similar in the two species. The coefficient of difference (Mayr *et al.*, 1953, p. 146) between the mean values of L/ML for specimens over 12·0 mm. length in each sample is less than 0·40, indicating that there would be a joint non-overlap of less than 60% between the individual L/ML values of the populations from which the samples were drawn. This degree of non-overlap is far below the conventional level of subspecific difference (90%, Mayr *et al*, *loc. cit.*).

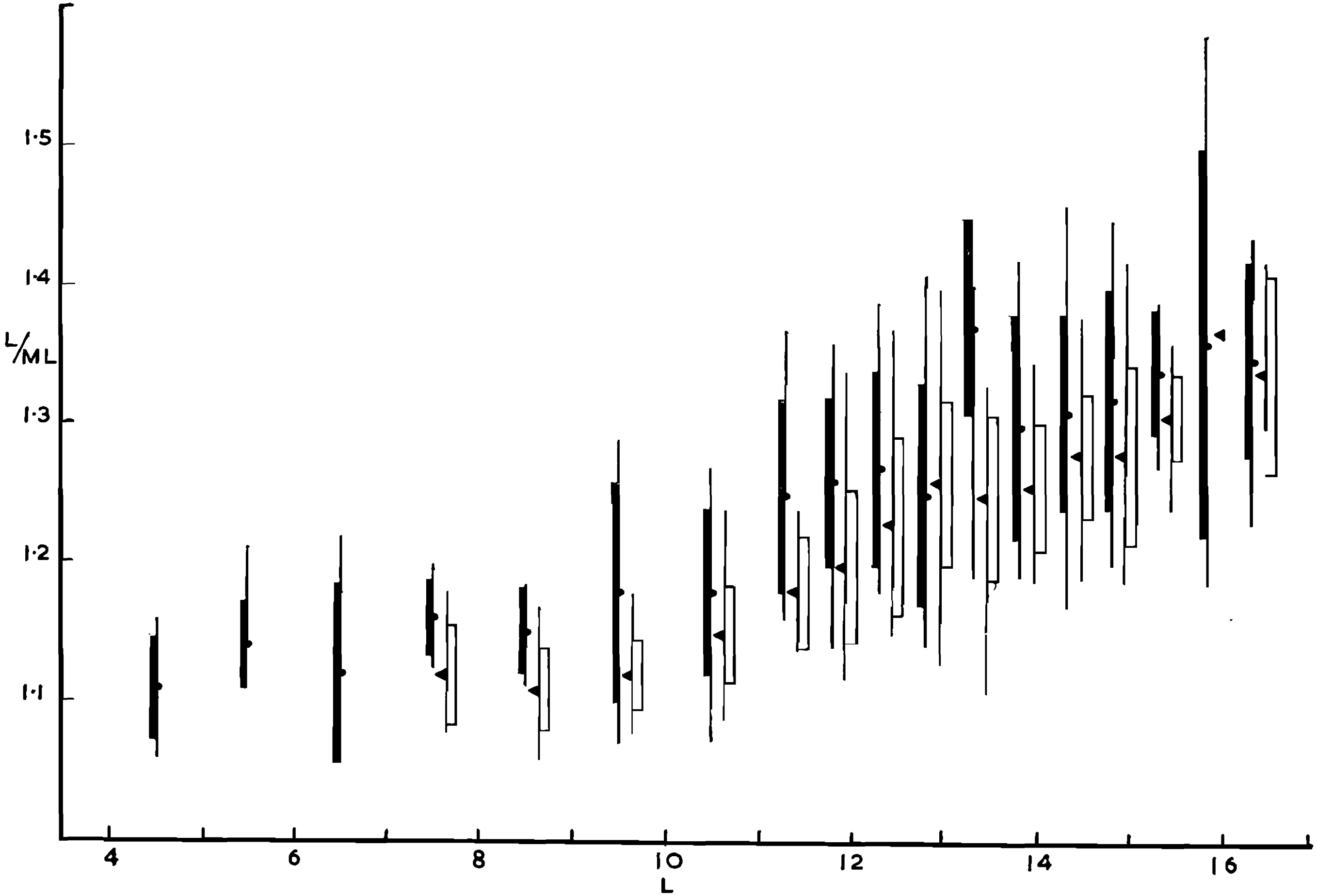

Fig. 4. *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*. The means and ranges of L/ML for specimens in corresponding class intervals of shell length. Range indicated by vertical line; one standard deviation on either side of the mean represented by an unfilled bar (*africanus*) or solid bar (*globosus*).

TABLE 2.

B. (*P.*) *africanus* and *B.* (*P.*) *globosus*. Relationship between shell length (L) and aperture length (ML)
Class intervals of L include 1·0 or 0·5 mm.; e.g. 4·95—5·95 mm. in the 5·0 interval
n, number of specimens

Class interval of L	*B.* (*P.*) *africanus* Umhlangana River, Durban			*B.* (*P.*) *globosus* Lagoa Dalagosa, Angola		
	n	Standard deviation	Mean L/ML	n	Standard deviation	Mean L/ML
5·0	—	—	—	10	·031	1·14
6·0	—	—	—	7	·064	1·12
7·0	8	·035	1·12	5	·027	1·16
8·0	12	·030	1·11	6	·033	1·15
9·0	14	·026	1·12	13	·075	1·18
10·0	27	·035	1·15	9	·063	1·18
11·0	7	·041	1·18	17	·065	1·25
11·5	14	·056	1·20	10	·057	1·26
12·0	23	·064	1·23	15	·066	1·27
12·5	26	·060	1·26	22	·075	1·25
13·0	24	·059	1·25	25	·080	1·37
13·5	24	·047	1·26	9	·079	1·30
14·0	28	·044	1·28	18	·069	1·31
14·5	18	·064	1·28	14	·076	1·32
15·0	10	·033	1·31	8	·044	1·34
15·5	2	·000	1·37	5	·135	1·36
16·0	3	·071	1·34	5	·069	1·35

COPULATORY ORGAN

Abnormality

In one specimen of *B.* (*P.*) *globosus* the penis sheath was exceptionally small and in another animal, in which the penis sheath was absent, the vas deferens joined the preputium directly; in a further specimen the penis sheath was of normal size but was not connected to the preputium. No abnormalities were observed in the copulatory organs of *B.* (*P.*) *africanus*.

TABLE 3.

B. (*P.*) *globosus*. Lagoa Dalagosa, Angola. Total length of the copulatory organ compared between specimens infected and uninfected with larval trematodes.
Class intervals of L include ranges of 1·0 or 0·5 mm., e.g., 10·95—11·45 in the 11·0 interval
Class intervals as in Table 1
*, number of specimens
P, probability that (a—b) is due to chance

Class interval of L	Total length copulatory organ		a—b	P
	Uninfected a	Infected b		
11·0	8·78 (11)*	7·80 (3)	0·98	0·10
11·5	9·45 (4)	5·72 (5)	3·73	0·05
12·0	10·36 (3)	9·20 (5)	1·16	0·30
13·0	10·87 (10)	9·05 (4)	1·82	0·01
14·0	10·31 (6)	8·95 (9)	1·36	0·40
14·5	11·92 (4)	8·26 (6)	3·60	0·10

Infection with larval trematodes

The total length of the copulatory organ in uninfected specimens of *B.* (*P.*) *globosus* was greater than in infected specimens in all six size groups examined (table 3), the difference being particularly significant in the 13·0 class interval (P = 0·01). However, the response of individual snails to parasitism was very variable, the copulatory organ being normal in some specimens whereas in others of the same size it had not grown beyond a rudimentary stage. The relative lengths of penis sheath and preputium did not differ significantly between infected and uninfected specimens.

Penis sheath and preputium

B. (*P.*) *africanus*

The extreme values of the ratio penis sheath length: preputium length (PS/PP) were 0·76 and 2·07. Copulatory organs having the penis sheath shorter than the preputium were present in only four specimens, and in all class intervals between shell lengths of 7·5 and 15·9 mm. the mean values of PS/PP exceeded 1·25 (table 4 and fig. 5). There appeared to be no significant change in the relative lengths of these parts of the copulatory organ over the size range studied.

In all the specimens the penis sheath at its widest part was equal in thickness or, in the majority, conspicuously thicker than the preputium. The penis sheath was broadest near to its proximal end (fig. 3).

B. (*P.*) *globosus*

As the presence of larval trematodes had been found to produce no significant effect upon the ratio PS/PP, all specimens were treated together for the study of this character-

TABLE 4

B. (*P.*) *africanus* and *B.* (*P.*) *globosus*. Relationship between length of penis sheath (PS) and preputium (PP)
Specimens with shell length less than 9·0 mm. grouped together: other class intervals as in Table 2
n = number of specimens
P = probability that difference between means of PS/PP for *africanus* and *globosus* is due to chance

Class interval of L	*B.* (*P.*) *africanus* Umhlangana River, Durban			*B.* (*P.*) *globosus* Lagoa Delagosa, Angola			P
	n	Standard deviation	Mean PS/PP	n	Standard deviation	Mean PS/PP	
7·5—8·9	7	0·385	1·39	6	0·139	0·87	·02—·05
9·0	13	0·233	1·49	8	0·363	0·96	<·01
10·0	27	0·233	1·43	8	0·161	0·86	,,
11·0	7	0·168	1·33	14	0·228	0·85	,,
11·5	14	0·192	1·27	7	0·153	0·84	,,
12·0	23	0·199	1·38	8	0·164	0·83	,,
12·5	26	0·182	1·31	14	0·089	0·84	,,
13·0	24	0·166	1·26	15	0·156	0·81	,,
13·5	24	0·163	1·27	7	0·138	0·81	,,
14·0	29	0·130	1·27	14	0·181	0·86	,,
14·5	18	0·190	1·30	9	0·171	0·89	,,
15·0	12	0·181	1·29	6	0·149	0·85	,,
16·0	3	0·274	1·04	—	—	—	—

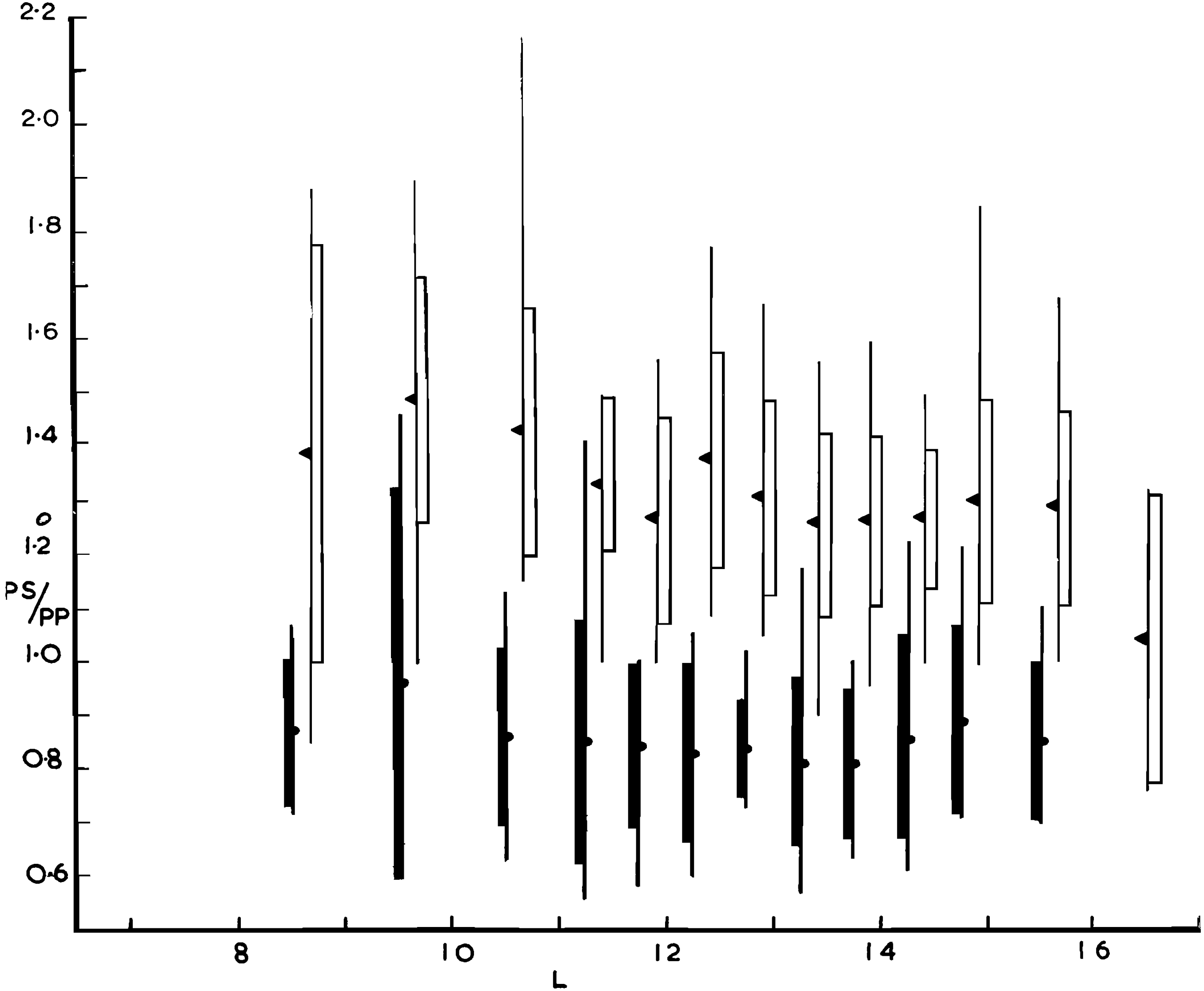

Fig. 5. *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*. The means and ranges of PS/PP for specimens in corresponding class intervals of shell length. Range indicated by vertical line; one standard deviation on either side of the mean represented by an unfilled bar (*africanus*) or a solid bar (*globosus*).

istic. The extreme values of PS/PP were 0·56 and 1·41. In the majority of specimens the penis sheath was shorter than the preputium, and although some individuals in which the penis sheath was longer were present in many class intervals of shell length, the majority of the mean values of PS/PP did not exceed 0·90 (table 4 and fig. 5). There appeared to be no significant change in the relative lengths of these parts of the copulatory organ over the size range studied.

The penis sheath at its widest part was narrower than the preputium in the majority of large specimens, and the point of maximum thickness was usually situated further from the proximal end of the organ than in *B.* (*P.*) *africanus* (fig. 2). Copulatory organs in which the penis sheath was as broad, or broader than the preputium were present more frequently in smaller specimens, giving a significantly higher ratio width penis sheath; width preputium in specimens of less than 12·0 mm. shell length (table 5).

TABLE 5.

B, (*P,*) *globosus* from Lagoa Dalagosa. Angola, Relationship between width of penis sheath (PS) and width of preputium (PP), based on measurements to nearest 0·1 mm.

L, shell length
n, number of specimens
P, probability that difference between means for specimens of > and < 12.00 mm. shell length is due to chance.

Class interval of L in mm.	n	Mean ratio width PS: width PP		Standard deviation of individual values	P
7·5—8·9	3	1·08	0·91	0·229	< 0·01
9·0—9·9	4	0·96			
10·0—10·9	6	1·03			
11·0—11·9	12	0·79			
12·0—12·9	12	0·73	0·73	0·185	
13·0—13·9	11	0·74			
14·0—14·9	13	0·67			
15·0—15·9	8	0·83			

The differences between the mean values of PS/PP for *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus* were highly significant ($P = \cdot 01$) in all class intervals above 9·0 mm. (table 4). The coefficient of difference (Mayr *et al.*, 1953) between the mean values of PS/PP for the specimens of each species over 12·0 mm. shell length is 1·16, indicating a joint non-overlap of approximately 90% between the individual values of PS/PP in the populations from which the samples were drawn. This degree of non-overlap corresponds to the conventional level of subspecific difference (Mayr *et al.*, *loc. cit.*); specimens of less than 12·0 mm. shell length gave a slightly lower joint non-overlap of 88 %.

The observations described above indicate that approximately 10% of the individual values of PS/PP for the *africanus* population would be overlapped by 10% of the values for the *globosus* population. As the majority of the individuals in the area of overlap could be assigned to their own population on the basis of the relative thickness of the penis sheath and preputium, it may be concluded that the ratio PS/PP, considered in conjunction with the relative thicknesses of these parts of the copulatory organ, is a valuable characteristic for the identification of these species. Because of the greater variability of the thickness of the penis sheath in small individuals of the present sample of *B.* (*P.*) *globusus* it appears that diagnostic features of the copulatory organ may be most consistent in specimens of more than 12·00 mm. shell length, a size at which sexual maturity has usually been reached (unpublished observations).

TABLE 6.

The relative lengths of penis sheath and preputium in samples of *Bulinus* (*Physopsis*) from south eastern Africa.
*author's collection number

	Locality	*number specimens*	*Mean PS/PP*	*Range PS/PP*	*Identification*
1.	Near Newington, Tvl. (505)*	5	0·69	0·57—0·78	globosus
2.	20 miles N. of Manhica, Mozambique. (466)	5	0·71	0·54—1·00	,,
3.	Near Newington, Tvl. (26)	5	0·76	0·67—0·81	,,
4.	Thabina River, near Tzaneen, Tvl. (454)	6	0·78	0·57—1·27	,,
5.	Near Tete Pan, Makatini Flats, Natal (56)	6	0·91	0·70—1·10	,,
6.	Near Tete Pan, Makatini Flats, Natal. (58)	5	0·94	0·81—1·14	,,
7.	Near Newington, Tvl. (22)	9	0·94	0·71—1·20	,,
8.	Near Newington, Tvl. (10)	10	0·95	0·88—1·13	,,
9.	Dangu River, Nkwaleni Valley (north of Eshowe), Natal (50)	7	0·95	0·80—1·08	africanus
10.	Mlandobjwala river, N.W. of Nongoma, Natal (46)	10	1·08	0·83—1·37	,,
11.	Umgeni river, near Wartburg, Natal (93)	15	1·10	0·91—1·53	,,
12.	Denny Dalton, Natal(48)	7	1·13	0·94—1·27	,,
13.	Near Mkuse, Natal (409a)	13	1·13	0·66—1·52	globosus
14.	Adams Mission, Durban (627)	10	1·16	0·84—1·45	africanus
15.	Near Adams Mission, Durban (81)	10	1·20	0·93—1·36	,,
16.	Port Shepstone, Natal (503)	10	1·20	0·97—1·74	,,
17.	Colenso, Natal (38)	5	1·20	1·00—1·43	,,
18.	Inyezane River, near Eshowe, Natal (382)	5	1·21	1·13—1·33	,,
19.	Babanango, Natal (198)	10	1·22	1·00—1·52	,,
20.	Ncanaweni River near Stanger, Natal (351)	5	1·28	1·13—1·58	,,
21.	Amahlongwa River, near Umzinto, Natal (359)	5	1·28	1·12—1·45	,,
22.	Mhlangana River, Durban (68)	159	1·29	1·10—1·42	,,
23.	North west of Nongoma, Natal (47)	10	1·32	1·13—1·57	,,
24.	Dalton, Natal (169)	10	1·33	1·15—1·56	,,
25.	Chakas Kraal, Natal (347)	8	1·36	1·11—1·54	,,
26.	Ifafa Beach, Natal (322)	10	1·37	1·15—1·75	,,
27.	Umzinto, Natal (360)	5	1·43	1·25—1·60	,,
28.	Gingindhlovu, Natal (370)	5	1·43	1·32—1·53	,,
29.	Umzinto River, Esperanza, Natal (356)	5	1·48	1·18—2·13	,,
30.	Mid Illovo, Natal (133)	10	1·49	1·11—1·81	,,
31.	Etete River, Chakas Kraal, Natal (350)	10	1·59	1·27—1·95	,,

Means PS/PP to nearest 0·1	*number of populations*
0·7	2
0·8	2
0·9	4
1·0	0
1·1	3
1·2	6
1·3	5
1·4	4
1·5	2
1·6	1

Values for samples 9 and 13 omitted for reasons explained in text.

B. (*P.*) *africanus* AND *B.* (*P.*) *globosus* IN SOUTH EASTERN AFRICA

Materials and methods

At least five sexually mature snails (more than 12·00 mm. in shell length) were examined from each of thirty one samples of *Bulinus* (*Physopsis*) collected from localities in the eastern part of the Republic of South Africa and Mozambique (table 6). Measurements of the copulatory organ were made in the manner described in the first part of this paper.

Copulatory organ

The mean value of the ratio length penis sheath: length preputium (PS/PP) for each sample is indicated in fig. 6 together with the range of the individual values; variation of the sample means is discontinuous, there being a major break in the distribution of values between 0·95 and 1·08. Special significance may be attached to this discontinuity because it separates two groups of samples, that with high values of PS/PP having the penis sheath thicker than the preputium, whereas the group with low values has the penis sheath thinner than the preputium.

The two samples which do not conform to this grouping, numbers 9 and 13, appear to occupy anomalous positions for different reasons. Larval trematodes were present in the majority of snails from locality 13 and apparently caused the development of abnormally small, attenuated copulatory organs. The contracted condition of many of the penis sheaths resulted in a low sample mean PS/PP for locality 9 although the penis sheath was very much thicker than the preputium in all the specimens. Had non-parasitised or better relaxed specimens been available from these two localities it is likely that the sample means of PS/PP would have conformed to the grouping showed by the other samples. In further discussion the lower group of samples indicated by the broken line in fig. 6 with the addition of number 13 will be referred to as *B.* (*P.*) *globosus* and the upper group with the addition of number 9 as *B.* (*P.*) *africanus.* If the mean values of PS/PP for samples 9 and 13 are left out of consideration, the remaining sample means show a clearly bimodal distribution (Table 6).

A large part of the intra-sample variation of PS/PP was produced by differential contraction of the two parts of the copulatory organ. For example, the highest value in the range for sample number 7 was obtained from a copulatory organ in which the preputium but not the penis sheath was contracted, and the lowest value for sample number 10 was that of a specimen in which only the penis sheath was contracted. The overlap between these samples ranges of PS/PP is thus partly due to the effects of fixation upon the copulatory organ. Although there is considerable overlap between the ranges of PS/PP for other *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus* samples, it is important to notice that the overlapping values are from copulatory organs in which the relative thicknesses of the penis sheath and preputium are consistent with the other specimens in their sample. For this reason it did not appear that any of the samples were mixtures of the two species.

Distribution

The geographical distribution of the samples (fig. 7) indicates that *B.* (*P.*) *africanus* has an extensive range in the central and southern parts of Natal whereas *B.* (*P.*) *globosus*

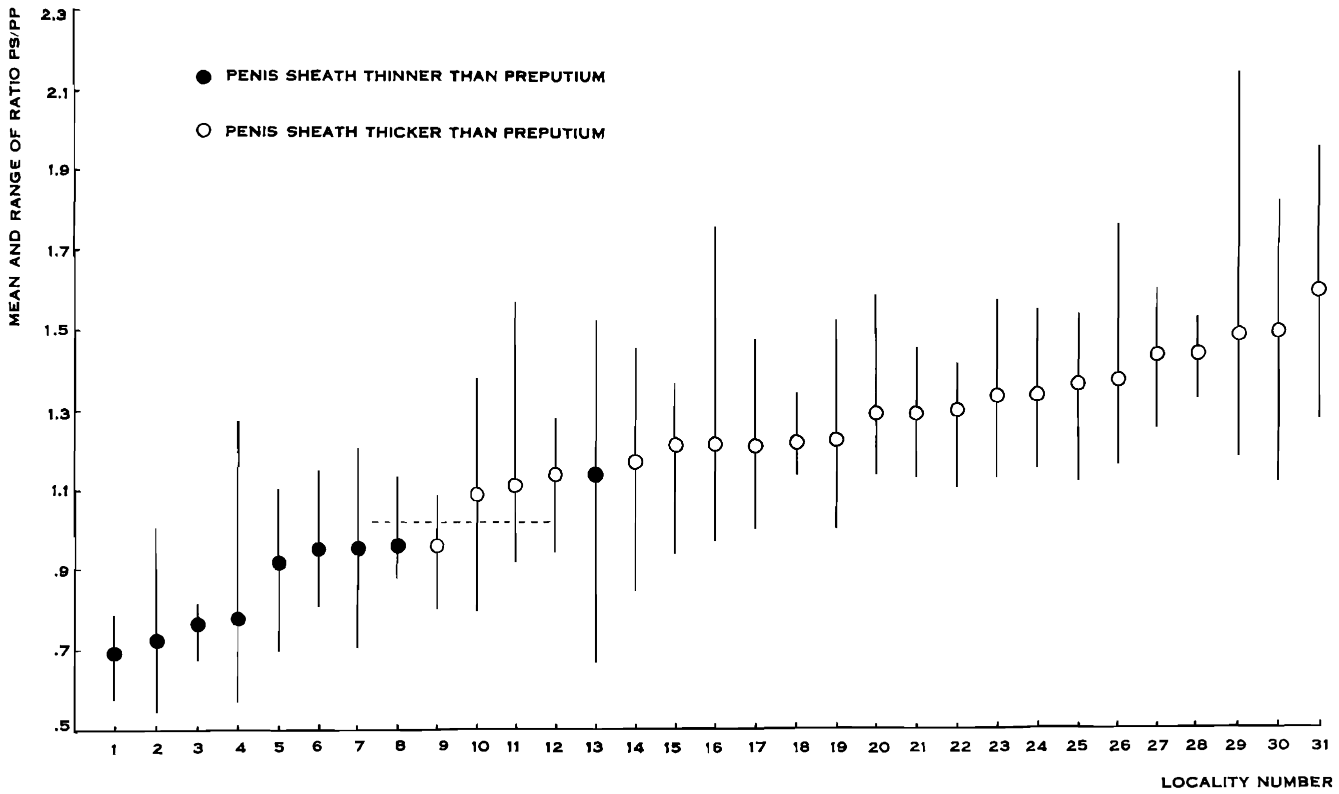

Fig. 6. *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*. The means and ranges of PS/PP for samples from localities in south eastern Africa. Numbers refer to the localities listed in Table 6.

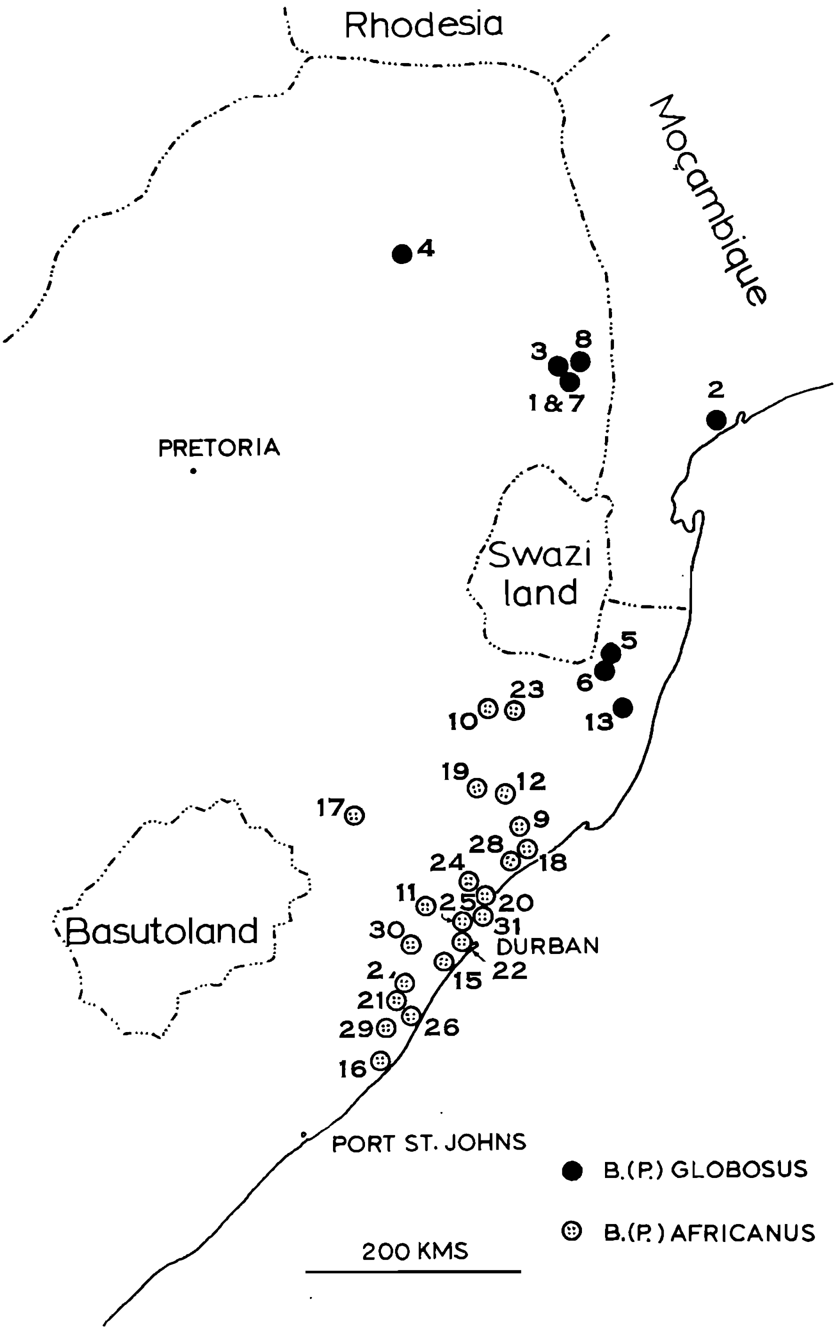

Fig. 7. *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*. Distribution of samples examined in the present investigation.

may occur only in the north eastern part of this province. All of the small number of samples examined from eastern Transvaal and Mozambique were *B.* (*P.*) *globosus* but *B.* (*P.*) *africanus* is also known to occur in this area.

DISCUSSION

Differences between shells of *B.* (*P.*) *africanus* from Durban and *B.* (*P.*) *globosus* from Angola or eastern Transvaal in the truncation of the columella were slight, but in samples of *B.* (*P.*) *globosus* from northern Natal truncation was relatively poorly developed. This characteristic was also observed by Mandahl-Barth (1957) and Azevedo *et al.* (1961) in some populations of *B.* (*P.*) *globosus*, but characteristics of the copulatory organ provide the most reliable means of identifying this species.

There are two records of *B.* (*P.*) *globosus* from localities to the south of the area of distribution found in the present investigation, of which that by Porter (1938) for the Durban area was presumably based upon shell characters and may therefore be incorrect. The record by Mandahl-Barth (1960) for Port Shepstone, Natal referred to two specimens of somewhat uncertain relationships (Mandahl- Barth, pers. comm.), so that it seems likely that *B.* (*P.*) *globosus* may reach the southern limit of its range in northern Natal.

In some parts of their ranges *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus* appear to be sympatric (Mandahl-Barth 1957, 1960; Azevedo *et al.*, 1961; Van Eeden in Schutte and Frank, 1964). However, *B.* (*P.*) *africanus* alone has been found on the plateau in southern Angola (Wright, 1963) and south of latitude 29° in eastern South Africa. It appears that there may be ecological differences between these species, because although Mandahl-Barth (1957) mentions the occurrence of both in the same locality, Azevedo *et al.* (1961) recorded *africanus* in 72 localities and *B.* (*P.*) *globosus* in 128, in only 17 of which they were both present.

The present distributions of *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus* in southern Africa may reflect ecological differences and also different routes of origin from a possible evolutionary centre in the region of Tanganyika (Wright, 1961). *B.* (*P.*) *africanus*, or stock from which it was derived, may have been the first form to extend its range down the eastern side of Africa, spreading up the Zambezi system into Angola (Wright, 1963). *B.* (*P.*) *globosus* may have originally become adapted to ecological conditions in the tropical parts of Africa, radiating westwards into Angola and southwards into Mozambique later than the *africanus* stock. From the abundance of *globosus* in Mozambique and eastern Transvaal this species appears to be at least as successful as *africanus* and it may be actively extending its range further southwards in Natal. On the other hand, the present southernmost limit of *globosus* may be determined by the adverse effect of cool climatic conditions to which *africanus* appears to be more successfully adapted.

SUMMARY

A detailed comparison between samples of *Bulinus* (*Physopsis*) *africanus* and *B.* (*P.*) *globosus*, collected from the regions of their type localities, was carried out for the copulatory organ and certain aspects of shell form. The results may be briefly summarised.

1. Parasitism by larval trematodes did not appear to have any significant effect upon the ratio of shell length: aperture length (L/ML) of *globosus.*

2. The shells of both *africanus* and *globosus* showed allometric growth, the aperture tending to be relatively shorter in larger specimens. Change in proportions was most marked between shell lengths of approximately 10·0 and 12·0 mm.

3. Although the spire tended to be slightly higher in *globosus*, this difference between the species did not appear to be significant.

4. Parasitism with larval trematodes produced a significant reduction in the length of the copulatory organ in many specimens of *globosus*, but did not appear to affect the relationship between the lengths of the penis sheath and preputium.

5. The penis sheath of *africanus* was consistently longer and thicker than the preputium. The mean ratio of penis sheath length: preputium length (PS/PP) was 1·29 for specimens 12·0 mm. shell length; there appeared to be no significant change in the ratio PS/PP over the size range 7·5 to 16·9 mm. shell length.

6. The penis sheath of *globosus* was shorter and thinner than the preputium in the majority of specimens. The mean ratio PS/PP was 0·84 for specimens 12·0 mm. length; there appeared to be no significant change in PS/PP over the size range 5·0 to 15·9 mm. shell length. The frequency of specimens with the penis sheath as thick, or thicker than the preputium was significantly greater in the size group of less than 12·0 mm. shell length.

7. It is concluded that characteristics of the copulatory organ provide a valuable means of identifying *B.* (*P.*) *africanus* and *B.* (*P.*) *globosus*, particularly applicable to specimens of more than 12·0 mm. shell length.

In a series of thirty-one locality samples, *B.* (*P.*) *africanus* was found to be widely distributed in central and southern Natal, whereas *B.* (*P.*) *globosus* occurred only in the northern part of this province. It is suggested that the different southern limits of distribution may reflect ecological differences between the species.

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